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ScienceDirect

Physics of Life Reviews 24 (2018) 21–23

PHYSICS of LIFE reviews

www.elsevier.com/locate/plrev

Comment

Upgrading Gestalt psychology with variational neuroethology: The case of perceptual pleasures
Comment on "Answering Schrödinger's question: A free-energy formulation" by M.J. Desormeau Ramstead et al.

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Received 29 December 2017; accepted 3 January 2018
Available online 5 January 2018
Communicated by J. Fontanari

Ramstead et al. provide a promising, encompassing framework for biology and psychology, based on the free energy principle (FEP) and Tinbergen's four questions [16]. Because their exposition remains at a fairly high level of abstraction, here we attempt to illustrate the potential of the framework through a concrete, classic case in psychology, namely that of our preference or liking of perceptual inputs. Two dominant but different views can be found in the literature. One harks back to the great Gestalt psychologists of the last century and stresses the salient and positive qualities of the 'goodness of form' or *Prägnanz*, i.e., orderly, balanced and coherent configuration [20,21]. Inputs that allow the formation of those "good Gestalts" would be most attractive. Later on, other authors added a role for learning (mere exposure) and argued that we prefer very familiar, regular or prototypical stimuli (e.g., [2]). However, these stimuli are quickly considered boring [3] and more importantly, highly attractive stimuli rarely conform to the principle (cf. art), partly discrediting the view.

The second view has Berlyne as its most famous proponent. He theorized that we seek out and like stimuli with a medium level of complexity [1], associated with medium level of arousal. While the idea that there is a moderate amount of novelty, unpredictability or complexity that is most pleasing, has received some empirical support (e.g., [13]), it remains descriptive rather than explanatory (on the different levels of Tinbergen). A key difficulty and arguably the reason why empirical studies have not provided unequivocal support for the inverted U-shape relation between complexity and preference, is the specification of complexity. Most scholars tried to objectify complexity as data complexity, often using simplified proxies (for example in terms of number of features or elements in a stimulus), while in fact we are interested in complexity of inputs given a particular (hierarchical, generative) model used. For example, a face will not be a complex stimulus for an organism equipped with good generative models for this type of input (as humans are). As Ramstead et al. discuss, the FEP can help to spell this out (see also [9]). Indeed, when the learned predictions of viewer are properly modeled (and complexity becomes the surprisal of inputs), the inverted U-shape relation of complexity and preference is clearly obtained [15].

Note that with this subjective conceptualization of complexity, being sensitive to a medium level of complexity means identifying the region of input space where most learning progress can be made given the current state of

DOI of original article: https://doi.org/10.1016/j.plrev.2017.09.001.
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https://doi.org/10.1016/j.plrev.2018.01.002

the observer's models. Specifically, it means avoiding on the one hand those stimuli that are overlearned and hence completely predictable, and on the other hand stimuli that are purely random (unlearnable) or still too unpredictable because the organism lacks models to deal with them [14,17]. Being able to estimate where learning progress can be made or, differently put, where reducible prediction errors (free energy) are situated, is of great value for organisms that rely disproportionally on learning instead of instincts for survival (cf. Tinbergen's function or adaptation). Phylogenetically, it allowed for efficient, gradual exploration for (infant) humans that have an enormous amount to learn but finite resources to do so. Indeed, addressing Tinbergen's ontogenesis question, we see the emergence of selective preference to stimuli of medium complexity from very early on in development (infants from 7- to 8-month-old; [11]). It may have been one of the key factors that enabled the "crossing of the evolutionary Rubicon", bootstrapping the explosion of human cultural learning into divergent cultural niches. An organism that builds expectations on reducibility of prediction errors (expected rate of change in free energy; [8,19]), will keep on learning to fulfill those expectations. Studies in ethology or comparative psychology will need to clarify to what extent other (mammal) species share the acute sensitivity to optimal levels of complexity relative to acquired or innate models, and the capacity to form such "meta-expectations".

Finally, what can we, with our current knowledge, say about Tinbergen's last question, that of the neurocognitive mechanism at play in perceptual preference and pleasure? The answer is partly in the emerging field of neuroscience of curiosity, intrinsic motivation, "free ranging" attention, and preference (e.g., [5,6,10]), which we do not have the space here to review. Rather, we will look at the answer Eysenck came up with in 1942 in the form of his "law of aesthetic appreciation": "The pleasure derived from a percept as such is directly proportional to the decrease of energy capable of doing work in the total nervous system, as compared with the original state of the whole system" [4, p. 358]. Eysenck acknowledged his indebtedness to Gestalt psychologists Köhler and Koffka. Indeed, Köhler wrote: "in all processes which terminate in time-independent states, the distribution shifts towards a minimum of energy" [12, p. 250]. A few things stand out in Eysenck's law. First, it emphasizes that aesthetic pleasure has much to do with frugal use of energetic resources. Second, compared to the initial gestaltists' 'static' view of preference for regularity, coherence and symmetry, this one has a decidedly dynamic nature. It emphasizes that pleasure is proportional to a change ('decrease') in energy, paralleling the change in free energy of recent approach FEP (or predictive processing) accounts of pleasure [8,19]. Third, the law remains vague on how to relate 'energy' to neurocognitive variables. One page earlier, Eysenck writes: "those external stimuli will be judged the most beautiful which are most in agreement with the internal forces of perception" [4, p. 357]. Again, what those internal forces are is not well specified, but we can make an attempt to fill this in using FEP. These internal forces would then be equated with the models (priors or predictions) one's perceptual system has about the world. If the inputs increasingly match these predictions, positive appreciation results.

Crucially, to align the FEP view with Eysenck's, the 'energy capable of doing work', also called Helmholtz free energy, should be proportional to informational free energy. However, Friston's free energy is an information-theoretic quantity first used in statistical physics, only called free energy because of its formal similarity (common probabilistic basis) with Helmholtz free energy. Still, as Sengupta, Stemmler, and Friston [18] prove, there is a close link between the two. The full argument is rather technical, but the basic conclusion is that "commonly occurring representational states—that are a priori most probable—are the least [metabolically] costly" [18, p. 9]. This implies that unlikely or unpredicted (surprising) inputs, i.e., with lots of prediction errors, have high metabolic cost. Hence, Helmholtz free energy and information-theoretic free energy share the same minimum (equilibrium). An interesting re-evaluation awaits here of old Gestalt ideas (e.g., the minimum energy idea, isomorphism, etc.) in the light of these new developments linking thermodynamics to informational concepts of order (predictability) and complexity. Although the details differ from what Gestaltists proposed, the basic intuition about the connection between Gestalt formation and thermodynamic, bioenergetic processes may still be validated.

To sum up, we could plausibly attribute the pleasure or preference to the internal progress made in representing the input in a sparse and efficient way. Indeed, it can be shown that minimizing prediction errors (free energy) as described by FEP, is equivalent to finding the so-called minimum description length (given Gaussian noise; [7]). A telling example is the Dalmatian "illusion" (or other so-called Mooney images): the newly found structure ("there's a dog in there") can summarize the disparate inputs best (the particular spatial configuration of black and white surfaces). Settling on a model (learned by prior experience, for example a model of a dog) that allows predictive progress seems marked by pleasure, especially if it happens suddenly or unexpectedly (faster than expected reduction of free energy). Yes, when explicitly asked, we will often report we like the predictable, well-structured or symmetric stimulus most (as the Gestaltists would have it), but that is presumably only because we often confuse end-product with the process needed to get there. And yes, stimuli of medium level of complexity are those that have the greatest potential for actual predictive progress, so will appear to be liked most (consistent with Berlyne and followers) when we confuse starting point with process.

We hope to have illustrated that FEP throws new light on Eysenck's and Berlyne's law, and the link between liking and thriftiness in the brain. More broadly, we see that the variational neuroethology framework can reconcile the two different views we started with and has the potential to drive the study of perceptual pleasures forward, by embedding it in its ontogenetic and phylogenetic context, including its role in moving to the sociocultural layer of organization.

Acknowledgements

Sander Van de Cruys is a postdoctoral fellow of the Research Foundation – Flanders (FWO). This work is supported in part by the Methusalem program by the Flemish Government (METH/14/02), awarded to Johan Wagemans. Some parts have been adapted from an unpublished chapter of the author's PhD dissertation.

References

[1] Berlyne DE. Novelty, complexity, and hedonic value. Percept Psychophys 1970;8(5):279–86. https://doi.org/10.3758/BF03212593.
[2] Bornstein RF. Exposure and affect: overview and meta-analysis of research, 1968–1987. Psychol Bull 1989;106(2):265–89. https://doi.org/10.1037/0033-2909.106.2.265.
[3] Bornstein RF, Kale AR, Cornell KR. Boredom as a limiting condition on the mere exposure effect. J Pers Soc Psychol 1990;58(5):791–800. https://doi.org/10.1037/0022-3514.58.5.791.
[4] Eysenck HJ. The experimental study of the "good Gestalt"—a new approach. Psychol Rev 1942;49(4):344–64. https://doi.org/10.1037/h0057013.
[5] Friston KJ, Adams RA, Perrinet L, Breakspear M. Perceptions as hypotheses: saccades as experiments. Front Psychol 2012;3. https://doi.org/10.3389/fpsyg.2012.00151.
[6] Gottlieb J, Oudeyer P-Y, Lopes M, Baranes A. Information-seeking, curiosity, and attention: computational and neural mechanisms. Trends Cogn Sci 2013;17(11):585–93. https://doi.org/10.1016/j.tics.2013.09.001.
[7] Huang Y, Rao RPN. Predictive coding. Wiley Interdis Rev Cogn Sci 2011;2(5):580–93. https://doi.org/10.1002/wcs.142.
[8] Joffily M, Coricelli G. Emotional valence and the free-energy principle. PLoS Comput Biol 2013;9(6):e1003094. https://doi.org/10.1371/journal.pcbi.1003094.
[9] Jost J. External and internal complexity of complex adaptive systems. Theory Biosci (Theor Biowiss) 2004;123(1):69–88. https://doi.org/10.1016/j.thbio.2003.10.001.
[10] Kidd C, Hayden BY. The psychology and neuroscience of curiosity. Neuron 2015;88(3):449–60. https://doi.org/10.1016/j.neuron.2015.09.010.
[11] Kidd C, Piantadosi ST, Aslin RN. The Goldilocks effect in infant auditory attention. Child Dev 2014;85(5):1795–804. https://doi.org/10.1111/cdev.12263.
[12] Köhler W. Die physischen Gestalten in Ruhe und im stationåren Zustand. Braunschweig, Germany: Vieweg; 1920.
[13] Krupinski E, Locher P. Skin conductance and aesthetic evaluative responses to nonrepresentational works of art varying in symmetry. Bull Psychon Soc 1988;26(4):355–8. https://doi.org/10.3758/BF03337681.
[14] Oudeyer P-Y, Kaplan F, Hafner VV. Intrinsic motivation systems for autonomous mental development. IEEE Trans Evol Comput 2007;11(2):265–86. https://doi.org/10.1109/TEVC.2006.890271.
[15] Piantadosi ST, Kidd C, Aslin R. Rich analysis and rational models: inferring individual behavior from infant looking data. Dev Sci 2014;17(3):321–37. https://doi.org/10.1111/desc.12083.
[16] Ramstead MJD, Badcock PB, Friston KJ. Answering Schrödinger's question: a free-energy formulation. Phys Life Rev 2018;24:1–16 [in this issue].
[17] Schmidhuber J. Formal theory of creativity, fun, and intrinsic motivation (1990–2010). IEEE Trans Auton Ment Dev 2010;2(3):230–47. Available from: http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5508364.
[18] Sengupta B, Stemmler MB, Friston KJ. Information and efficiency in the nervous system—a synthesis. PLoS Comput Biol 2013;9(7):e1003157. https://doi.org/10.1371/journal.pcbi.1003157.
[19] Van de Cruys S. Affective value in the predictive mind. In: Metzinger TK, Wiese W, editors. Philosophy and predictive processing. Frankfurt am Main: MIND Group; 2017.
[20] Wagemans J, Elder JH, Kubovy M, Palmer SE, Peterson MA, Singh M, et al. A century of Gestalt psychology in visual perception: I. Perceptual grouping and figure-ground organization. Psychol Bull 2012;138(6):1172–217. https://doi.org/10.1037/a0029333 (electronic).
[21] Wertheimer M. Untersuchungen zur Lehre der Gestalt, II. Psychol Forsch 1923;4:301–50.